

Amendments to the Claims:

1. (Withdrawn) A detection apparatus to detect magnetic fields comprising:
an first alteration element having a response curve to an applied
electromagnetic field, the response curve exhibiting hysteresis between a plurality of
stable states such that transition regions exist between the stable states;
a source of electromagnetic radiation, the electromagnetic radiation
impinging on the first alteration element;
a source of an alternating electromagnetic field applied to the first alteration
element, the alternating electromagnetic field of sufficient strength to switch the first
alteration element between the stable states, a characteristic of the electromagnetic
radiation being altered dependent on the alternating electromagnetic field and an
electromagnetic field of a subject; and
a detector configured to detect the characteristic of the electromagnetic
radiation impinging on the detector, the electromagnetic radiation impinging on the
detector having been altered when the first alteration element was in one of the transition
regions.
2. (Withdrawn) The detection apparatus of claim 1, wherein the
electromagnetic radiation is light and the characteristic is polarization of the light.
3. (Withdrawn) The detection apparatus of claim 1, further comprising an
amplification material disposed close enough to the first alteration element to amplify an
internal electromagnetic field of the first alteration element.
4. (Withdrawn) The detection apparatus of claim 1, wherein the alternating
electromagnetic field applied to the first alteration element comprises an alternating
electromagnetic field of high frequency during detection and a low frequency field to
remagnetize the first alteration element.
5. (Withdrawn) The detection apparatus of claim 1, wherein the detection
apparatus is configured to measure a magnetic field of a heart.

6. (Withdrawn) The detection apparatus of claim 1, wherein the detection apparatus is configured to track particles introduced intentionally to a human.

7. (Withdrawn) The detection apparatus of claim 1, further comprising a second alteration element having a response curve substantially identical to the first alteration element, the second alteration element disposed so as to be affected by the alternating electromagnetic field substantially identically as the first alteration element while remaining substantially unaffected by the electromagnetic field of the subject, the detector configured to detect the characteristic of the electromagnetic radiation from both the first and second alteration elements impinging on the detector that have been altered when the first and second alteration elements were in one of the transition regions and provide an output based on a difference between the characteristic of the electromagnetic radiation from the first and second alteration elements.

8. (Withdrawn) The detection apparatus of claim 1, wherein the detector is configured to detect the characteristic of the electromagnetic radiation impinging on the detector that has been altered only when the first alteration element was in one of the transition regions.

9. (Withdrawn) The detection apparatus of claim 1, further comprising an optimization apparatus to optimize the hysteresis characteristic such that an operating point is substantially maintained by adjusting at least one of an amplitude and a frequency of the alternating electromagnetic field to substantially maintain the operating point.

10. (Withdrawn) The detection apparatus of claim 9, wherein the optimization apparatus monitors the hysteresis characteristic and adjusts the alternating electromagnetic field only if the hysteresis characteristic has changed by a predetermined amount.

11. (Currently amended) A detection apparatus to detect weak magnetic fields comprising:

a first magneto-optical element that exhibits a response, in the form of Faraday rotation, to an applied magnetic field, a hysteresis characteristic of the Faraday rotation exhibiting transition regions between a plurality of stable states;

a light source to emit light that impinges on the first magneto-optical element;

a modulation element comprising a coil adjacent to the first magneto-optical element, the modulation element being a source of a time-varying magnetic field of sufficient strength to switch the first magneto-optical element between the stable states; and

a detector configured to detect a change in the light caused by a reaction of the first magneto-optical element to a weak magnetic field ~~of a subject~~, the change occurring when the first magneto-optical element is in one of the transition regions,

wherein the detection apparatus has a sensitivity sufficient to detect the weak magnetic field.

12. (Withdrawn) The detection apparatus of claim 11, wherein the modulation element is configured to apply a time-varying magnetic field of frequency substantially higher than 60 Hz.

13. (Original) The detection apparatus of claim 11, further comprising a magnetic material having a high permeability and disposed sufficiently close to the first magneto-optical element to amplify an internal magnetic field in the first magneto-optical element formed by an external magnetic field impinging on and penetrating the first magneto-optical element.

14. (Currently amended) The detection apparatus of claim 11, wherein the detector is configured in a gradiometer arrangement to subtract a background signal from a ~~subject~~an actual signal supplied from the first magneto-optical element affected by the weak magnetic field ~~of the subject~~.

15. (Currently amended) The detection apparatus of claim 11, further comprising a second magneto-optical element upon which the light impinges and that is

affected substantially the same as the first magneto-optical element by the time-varying magnetic field, the second magneto-optical element configured to be substantially unaffected by the weak magnetic field ~~of the subject~~ and supplying the background signal.

16. (Currently amended) The detection apparatus of claim 11, further comprising a trigger configured to detect an initialization signal from the weak magnetic field ~~of the subject~~ and transmit a trigger pulse to the detector.

17. (Original) The detection apparatus of claim 11, further comprising shielding to shield components of the detection apparatus from sources of electromagnetic radiation causing noise in the components.

18. (Currently amended) The detection apparatus of claim 17, wherein the shielding is configured to additionally shield a source of the weak magnetic field ~~of the subject~~.

19. (Currently amended) The detection apparatus of claim 17, wherein a source of the weak magnetic field ~~of the subject~~ remains uncovered by the shielding.

20. (Original) The detection apparatus of claim 11, further comprising a vibration-isolating platform on which components of the detection apparatus are disposed.

21. (Currently amended) The detection apparatus of claim 20, wherein the vibration-isolating platform is large enough to additionally hold a source of the weak magnetic field ~~of the subject~~.

22. (Original) The detection apparatus of claim 11, wherein the first magneto-optical element comprises a doped YIG thin film has a thickness of less than about three microns.

23. (Withdrawn) The detection apparatus of claim 22, wherein the YIG film is doped with at least Bi.

24. (Original) The detection apparatus of claim 22, wherein the YIG film is formed from amorphous or single crystal material.

25. (Original) The detection apparatus of claim 11, further comprising a single nonmagnetic frame upon which optical components of the detection apparatus are mounted.

26. (Original) The detection apparatus of claim 11, wherein the modulation element is configured to apply a time-varying magnetic field of high frequency during detection and a low frequency field to remagnetize the first magneto-optical element.

27. (Original) The detection apparatus of claim 11, wherein the excitation source is a laser.

28. (Original) The detection apparatus of claim 11, further comprising an expander to enlarge an area of light from the light source impinging on the first magneto-optical element.

29. (Withdrawn—Currently amended) The detection apparatus of claim 11, wherein the ~~detection apparatus is configured to measure a weak~~ magnetic field is provided by ~~of an organ or bodily system of an animal.~~

30. (Withdrawn—Currently amended) The detection apparatus of claim 11, wherein the ~~detection apparatus is configured to measure a weak~~ magnetic field is provided by ~~of an organ or bodily system of human.~~

31. (Withdrawn) The detection apparatus of claim 30, wherein the organ is a heart.

32. (Withdrawn) The detection apparatus of claim 31, further comprising a trigger configured to detect a cardiac pulse waveform and transmit a trigger pulse to the detector.

33. (Withdrawn) The detection apparatus of claim 11, wherein the detection apparatus is configured to track magnetic particles introduced intentionally to an animal.

34. (Original) The detection apparatus of claim 11, wherein the detector is characterized in that the change in the light detected is caused only when the first magneto-optical element was in one of the transition regions.

35. (Original) The detection apparatus of claim 11, further comprising an optimization apparatus to optimize the hysteresis characteristic such that an operating point is substantially maintained.

36. (Original) The detection apparatus of claim 35, wherein the operating point provides maximum magnetic field sensitivity.

37. (Original) The detection apparatus of claim 35, wherein the optimization apparatus adjusts at least one of an amplitude and a frequency of the time-varying magnetic field to substantially maintain the operating point.

38. (Original) The detection apparatus of claim 37, wherein the optimization apparatus comprises a detection element that detects the response of the first magneto-optical element and transmits an optimization signal to optimization electronics that measure a slope of the transition region near the operating point and provide feedback to the modulation element to adjust the time-varying magnetic field.

39. (Original) The detection apparatus of claim 38, wherein the optimization apparatus monitors the hysteresis characteristic of the first magneto-optical element and adjusts the time-varying magnetic field only if the hysteresis characteristic has changed by a predetermined amount.

40. (Currently amended) A method of detecting weak magnetic fields comprising:

providing a first magneto-optical element exhibiting a response, in the form of Faraday rotation, to an applied magnetic field, a hysteresis characteristic of the

Faraday rotation exhibiting transition regions between stable states, wherein the first magneto-optical element is in the presence of a weak magnetic field;

impinging light from a light source on the first magneto-optical element;
applying a time-varying magnetic field from a modulation element to the first magneto-optical element;
switching the first magneto-optical element between the stable states; and
detecting a change in the light caused by a reaction of the first magneto-optical element to ~~a~~the weak magnetic field ~~of a subject~~, the change occurring when the first magneto-optical element is in one of the transition regions.

41. (Previously presented) The detection method of claim 40, wherein the time-varying magnetic field has a frequency substantially higher than 60 Hz.

42. (Original) The detection method of claim 40, further comprising amplifying an internal magnetic field of the first magneto-optical element using a magnetic material disposed adjacent to the first magneto-optical element and having a high permeability.

43. (Currently amended) The detection method of claim 40, further comprising configuring components used in the detection method in a gradiometer arrangement to subtract a background signal from a subject signal supplied from the first magneto-optical element affected by the weak magnetic field ~~of the subject~~.

44. (Currently amended) The detection method of claim 40, further comprising providing a second magneto-optical element upon which the light impinges and that is affected substantially the same as the first magneto-optical element by the time-varying magnetic field, the second first magneto-optical element configured to be substantially unaffected by the weak magnetic field ~~of the subject~~ and supplying the background signal.

45. (Original) The detection method of claim 40, further comprising shielding components used in the detection method from sources of electromagnetic radiation causing noise in the components.

46. (Withdrawn—Currently amended) The detection method of claim 45, further comprising shielding a source of the weak magnetic field ~~of the subject~~.

47. (Currently amended) The detection method of claim 45, further comprising leaving a source of the weak magnetic field ~~of the subject~~ unshielded.

48. (Original) The detection method of claim 40, further comprising isolating components used in the detection method from vibrations.

49. (Currently amended) The detection method of claim 48, further comprising isolating a source of the weak magnetic field ~~of the subject~~ from the vibrations.

50. (Original) The detection method of claim 40, wherein the first magneto-optical element comprises a doped YIG thin film that has a thickness of less than about three microns.

51. (Withdrawn) The detection method of claim 50, wherein the YIG film is doped with at least Bi.

52. (Original) The detection method of claim 50, wherein the YIG film is formed from amorphous or single crystal material.

53. (Previously presented) The detection method of claim 40, further comprising applying a time-varying magnetic field of a low frequency for remagnetizing the first magneto-optical element.

54. (Original) The detection method of claim 40, further comprising expanding an area of the light emitted from the light source.

55. (Currently amended) The detection method of claim 40, ~~further comprising measuring a magnetic field of~~ wherein an organ or bodily system of an animal provides the weak magnetic field.

56. (Currently amended) The detection method of claim 40, ~~further comprising measuring a magnetic field of an organ or bodily system of a human~~ provides the weak magnetic field.

57. (Currently amended) The detection method of claim 40, ~~further comprising measuring the magnetic field of a heart~~ provides the weak magnetic field.

58. (Original) The detection method of claim 57, further comprising detecting a cardiac pulse waveform and transmitting a trigger pulse to initiate detection.

59. (Original) The detection method of claim 40, further comprising tracking magnetic particles introduced intentionally to an animal.

60. (Previously presented) The detection method of claim 40, wherein only the change in the light occurring when the first magneto-optical element is in one of the transition regions is detected.

61. (Original) The detection method of claim 40, further comprising optimizing the hysteresis characteristic such that an operating point is substantially maintained.

62. (Withdrawn) The detection method of claim 40, further comprising optimizing the hysteresis characteristic such that a maximum magnetic field sensitivity is substantially maintained.

63. (Original) The detection method of claim 61, further comprising adjusting at least one of an amplitude and a frequency of the time-varying magnetic field to substantially maintain the operating point.

64. (Original) The detection method of claim 63, further comprising detecting a magnetization of the first magneto-optical element, measuring a slope of the transition region near the operating point and providing feedback to adjust the time-varying magnetic field.

65. (Original) The detection method of claim 64, further comprising monitoring the hysteresis characteristic and adjusting the time-varying magnetic field only if the hysteresis characteristic has changed by a predetermined amount.

66. (New) The detection apparatus of claim 11, wherein the weak magnetic field is less than 100 pT.

67. (New) The detection method of claim 40, wherein the weak magnetic field is less than 100 pT.